MISSOURI DEPARTMENT OF NATURAL RESOURCES
Missouri Geological Survey

GeoSTRAT Worksheet

This activity is suitable for middle school students and learners of all ages who are interested in locating springs, mines, sinkholes and other geologic and hydrologic features using the online Missouri Geosciences Technical Resource Assessment Tool. GeoSTRAT is best viewed using Google Chrome or Mozilla Firefox browsers. An Internet connection, a Web browser, and the free Google Earth Plug-in are required to use the tool. Download it now or go directly to GeoSTRAT to get the plug-in.

Science Literacy and GeoSTRAT

As science educators across the state look at the Missouri Learning Standards, their thoughts turn to providing their students with rigorous content and the application of knowledge through higher-order thinking skills. Many are looking for a way to make the connection from content knowledge to applied science to give their students real-world skills using authentic data to answer real-world questions. As our state moves toward more sustainable use of our natural resources and a new, dynamic era of economic development, it is critical to prepare our students for the future. They will need to use critical thinking skills, plan and conduct research, manage projects, solve problems and make informed decisions. A tool that can help educators and students with this mission is the Missouri Department of Natural Resources' Web-based tool, GeoSTRAT.

Literacy Standards for middle school which are covered in this GeoSTRAT lesson include:

Key Ideas and Details:
CCSS.ELA-Literacy.RST.6-8.3
Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

Craft and Structure:
CCSS.ELA-Literacy.RST.6-8.4
Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to *grades 6-8 texts and topics*.

Integration of Knowledge and Ideas:
CCSS.ELA-Literacy.RST.6-8.7
Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).

Range of Reading and Level of Text Complexity:
CCSS.ELA-Literacy.RST.6-8.10
By the end of grade 8, read and comprehend science/technical texts in the grades 6-8 text complexity band independently and proficiently.

GeoSTRAT Uses

GeoSTRAT is a Web-based tool built using Google Earth and ESRI GIS mapping technology that makes satellite imagery and geologic and hydrologic data available to citizens, planners, industry, academia and others online 24/7. GeoSTRAT lets you "fly" anywhere in Missouri to see aerial views of the landscape and navigate and explore. It is used for data assessments in disciplines such as hazards assessment, environmental consulting and engineering, local and regional planning, insurance assessment and others.

This tool is invaluable to emergency personnel when natural or man-made disasters occur. Numerous data layers now compiled in GeoSTRAT were used to aid planners in properly locating sites for landfills for debris removal following the tornado that devastated Joplin in 2011. Having immediate access to abandoned mine and sinkhole locations that could collapse and result in groundwater contamination will be extremely beneficial in similar instances.

GeoSTRAT aids environmental consulting firms in conducting risk-based corrective action site investigations, geological mapping, groundwater monitoring, source evaluation, nature and extent investigations, environmental site assessments, feasibility studies and the design of groundwater monitoring networks.

Navigate to GeoSTRAT and Begin Exercise

Go to the GeoSTRAT Web page [dnr.mo.gov/geology/geostrat.htm] and click on the large GeoSTRAT image. Click "View Map" to open GeoSTRAT.

1. Bedrock geologic maps provide information about the existing layering of bedrock and faulting, folding or deformation (a change in the shape or dimensions, resulting from stress or strain). Bedrock geologic maps include information about the distribution of rock such as limestone, sandstone, coal, shale, granite and other rocks and minerals. Missouri's geology is quite diverse. Evidence of extinct volcanoes, glaciers, cave systems, earthquakes and old mines are just a few of the interesting things that make up Missouri.

- In the "Layers" column, on the left side of the screen, turn on the "Bedrock 1:500,000 scale" layer.
- Turn on the "Cities" layer and zoom in (using the plus (+) control on the slider bar in upper right region of the viewing window) to see St. Louis, Columbia, Independence and Springfield.
- Explore the various bedrock formations by clicking on areas as identified by different colors.
- In the search box (at the top of the map viewing area), type "Arcadia" and click the zoom button.
- Click on the red area inside the yellow lines that indicate the boundary lines for the town of Arcadia.

Q. *What is the name of this geologic formation and how did it form?*

A. _____

2. We depend on good quality water for drinking. For many Missourians, that water comes from a well. When wells are no longer used they should be properly closed.

- Close the report window by clicking on the "X" in the upper right corner of the report window.
- Turn off the "Bedrock 1:500,000 scale" layer.
- Search for this address: 900 Bulldog Run, Rolla.
- Click the zoom button and locate Rolla High School (center of the viewing window).
- Turn on the "Certified Wells" layer and locate the well between the building and baseball field.
- Click on the symbol that represents the well to see the well is an abandoned (closed) domestic well.

- Click on the PDF hyperlink and open the well record report PDF by clicking on the report in the lower left corner of the Web browser. You will see the report was submitted by the water well driller when the well was closed August 6, 2003.

Q. *What is the depth of this closed well and was the pump removed from the well?*

A. _____

3. Well cuttings are the broken bits of solid material removed from a borehole drilled by rotary, percussion, or auger methods. Well cuttings from throughout the state are stored at the Missouri Geological Survey's McCracken Core Library and Research Center.

- Close the PDF by closing the second tab at the top of the web browser, turn on the "Well Cuttings" layer.
- Click on the red well cuttings symbol located nearest the school.

Q. *At what depth did the water well driller hit bedrock and what is the total depth of the hole?*

A. _____

4. Sinkholes are depressed or collapsed areas formed by dissolution of carbonate bedrock or collapse of underlying caves. They range in size from several square yards to hundreds of acres and may be very shallow or hundreds of feet deep. Sinkholes are part of what is called "karst" topography, which also includes caves, springs and losing streams. Karst landscapes include easily weathered carbonate rocks such as limestone and dolomite. Missouri's southern region has many karst features. Sinkholes often serve as direct conduits (paths) for rapid surface water infiltration into the underlying groundwater aquifer. Contaminants near or at the surface can quickly enter the aquifer and pollute drinking water supplies. The Missouri Geological Survey has verified almost 16,000 sinkholes in Missouri. Many more exist that have not been reported or documented by staff.

- Close the report window and turn off the "Well Cuttings" and "Certified Wells" layers.
- Locate the search box again and click the "Full Extent" button (to the right of the "Zoom" button) to see the entire state. Based on the size of your viewing area you may need to scroll to the top to see the button.
- Turn on the "Sinkhole Points" layer.

Q. *Why do more sinkholes occur in the southern part of the state?*

A. _____

5. Missouri is blessed with an abundance of springs. The Missouri Ozarks comprises one of the nation's greatest concentrations of springs. They are one of Missouri's most important assets. Springs play a huge role in transporting groundwater.

- Turn off the "Sinkhole Points" layer.
- Turn on the "Springs" layer.
- Find "St. James."

Q. *What is the name of the spring situated between Rolla and Doolittle? What is the estimated flow rate (gallons per minute) for this spring?*

A. _____

6. In the lower right corner of the map area you will see a value associated with "eye alt," which indicates your altitude (in miles) above the surface. You may need to scroll down to see the eye alt value.

- Zoom in using the plus control on the slider bar in upper right side of the viewing window and set the "eye alt" value at approximately 25 miles.
- Place the cursor inside the map area, click, grab and move St. James and Rolla to the top of the screen.
- Find Maramec Spring, located southeast of St. James.

Q. *What is the maximum flow rate (cubic feet per second) at the spring?*

A. _____

7. Non-toxic fluorescent tracing dye is placed at locations where water flows underground. Sometimes, dye is place in sinkholes. Possible recovery points, such as springs, are monitored where the dye (or potential contaminants) may resurface. Recovery of the tracer proves it has moved through the geologic formations below the ground to that location. In November 1981, a leak from a fertilizer pipeline, containing ammonia, near the Phelps-Dent County line severely affected the quality of water discharging from Maramec Spring nearly 13 miles northeast of the site of the spill. The ammonia entered the subsurface through karst features and traveled underground to the spring. Low dissolved oxygen conditions severely damaged the trout population at the spring and several species of cave fauna that live in the spring system. The Missouri Geological Survey conducted a water trace study to definitively establish the hydrologic connection between the spill site and Maramec Spring. The effects of the ammonia on Maramec Spring's water quality could be detected for about seven weeks.

- Turn on the "Dye Injection Points," "Dye Paths" and "Dye Recovery Points" layers.
- Explore each of the five dye injection paths to learn about each water trace study.

Q. *What is the name of the "Dye Injection Point" that confirmed ammonia traveled from the spill site to Maramec Spring and what is the distance from the dye injection point to the spring?*

A. _____

8. Imagine you are the geologist in charge of approving a new landfill for St. James. Recall what you observed about the area geology and groundwater.

- Close the report window.
- Turn on the "Sinkhole Points" layer.

Q. *Are there any areas you would recommend the city NOT put a landfill and why?*

A. _____

_____

9. A herd of pink "elephants" can be found in southern Iron County. These pachyderms aren't performing in a circus or living in a zoo. They are huge elephant-shaped igneous rocks crowning the high point of the Missouri Department of Natural Resources' Elephant Rocks State Park. The herd of pink granite "elephants" weighs about 160 pounds per cubic foot and stands 20 to 30 feet tall. "Dumbo," the matriarch of the troop, weighs about 680 tons, stands 27 feet tall, and measures 35 feet long and 17 feet wide.

- Turn off the “Sinkhole Points,” “Dye Injection Points,” “Dye Paths,” “Dye Recovery Points” and “Springs” layers. Turn on the “Bedrock 1:500,000 scale” layer.
- Click the “Full Extent” button to see the entire state.
- Turn off the “Bedrock 1:500,000 scale” layer.
- Turn on the “Roads” and “State Parks and Historic Sites” layers.
- Search for “Elephant Rocks.”
- Zoom in and check out Elephant Rocks State Park and notice the terrain.
- Zoom out. Grab and move the cursor to see other state parks and historic sites located throughout the state.

Q. What is the name of the historic site located in the northern-most part of the state?

A. _____

Explore Further

Type your home address in the search box. Turn on and off layers, zoom in, out, grab and move the cursor and explore and identify geologic, hydrologic and other features.

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Additional Resources

Department of Natural Resources Youth Education
dnr.mo.gov/education

Ed Clark Museum of Missouri Geology
dnr.mo.gov/geology/edclarkmuseum.htm

Elephant Rocks – A Geologic Phenomenon
dnr.mo.gov/pubs/pub683.pdf

Elephant Rocks State Park
mostateparks.com/park/elephant-rocks-state-park

Environmental Assistance
dnr.mo.gov/geology/geosrv/envgeo/eau.htm

McCracken Rock Core Library and Research Center
dnr.mo.gov/geology/geosrv/geores/mccracken.htm

Maramec Pipeline Break
dnr.mo.gov/env/wrc/docs/MaramecPipelineBreak.pdf

Missouri Geological Survey Educational Outreach
dnr.mo.gov/geology/education.htm

Missouri Resources Magazine
dnr.mo.gov/magazine

Missouri State Parks
mostateparks.com

Sinkholes
dnr.mo.gov/geology/geosrv/envgeo/sinkholes.htm

Springs
dnr.mo.gov/env/wrc/springs.htm

Water Tracing Studies
dnr.mo.gov/magazine/docs/mr-summer-14.pdf#page=8

Water Wells
dnr.mo.gov/magazine/docs/mr-fall-2014.pdf#page=10

Wellhead Protection
dnr.mo.gov/geology/geosrv/wellhd

GeoSTRAT Worksheet Key

1. The formation name is St. Francois Mountains Volcanic Supergroup, and it formed as a result of volcanic activity.
2. The depth of the well is 50.0 feet (ft). Yes, the pump was removed from the well.
3. The well driller hit bedrock at 20 feet (ft) deep. Total depth of the hole is 1,710 feet (ft).
4. The southern part of Missouri has karst topography which includes easily weathered carbonate rocks like limestone and dolomite.
5. The spring between Rolla and Doolittle is named Martin Spring. Its estimated flow rate is 100 gallons per minute (gpm).
6. The maximum flow rate of Maramec Spring is 650 cubic feet per second (cfs).
7. Dry Fork is the name of the injection point. The distance to the spring is 12.755 miles (mi).
8. I would recommend the city not put a landfill near the sinkholes and springs to the southeast of town. Sinkholes can provide a route for transporting pollutants to other places such as underlying groundwater aquifers which can pollute our drinking water.
9. Battle of Athens State Historic Site is located in the northern-most part of the state.

Explore Further: Answers will vary.